

# Application of Technology in the Fault Diagnosis of Large Centrifugal Pump Units

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**Abstract:** In order to promote the stability of centrifugal pump units and maximize the role of centrifugal pumps, this paper analyzes the composition and basic working principle of centrifugal pumps, presents the main concerns of centrifugal pump maintenance, and finally investigates the common faults and maintenance methods of centrifugal pumps for reference.

**Keywords:** Centrifugal pump; Fault diagnosis; Detection technology; Daily operation and maintenance

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## 1. Introduction

As a type of fluid transportation equipment, centrifugal pump units play an important role in pipeline oil transportation production and the petrochemical industry's power hub. The centrifugal pump unit is distinguished by the following characteristics: large volume, with a weight of more than 100,000 tons; high energy consumption; high cost, with a single unit costing more than 100,000 yuan. Therefore, the management level of a centrifugal pump unit is directly related to the safety, stability, efficiency, and energy consumption of oil transportation production. It is particularly important to gauge and understand the common faults of centrifugal pump units <sup>[1]</sup>.

## 2. Structural composition and basic working principle of centrifugal pumps

### 2.1. Structure composition

Centrifugal pumps comprise of six parts.

#### (1) Impeller

As the core component of centrifugal pumps, it has remarkable characteristics, such as high speed and large output. Based on the important role of blades on the impeller, the static balance test needs to be carried out before assembly. The inner and outer surfaces of the impeller should be smooth to effectively reduce the friction loss caused by water flow.

#### (2) Pump body

The pump body is also known as the "pump shell." it is the main component of the water pump, which mainly plays the role of support and fixation. It is closely connected to the support for installing the bearing.

#### (3) Pump shaft

The primary function of the pump shaft is to effectively connect the coupling to the motor and transmit the torque of the motor to the impeller. Therefore, it can be used as a key component to transfer mechanical energy.

(4) Seal ring

The seal ring is also known as the “leakage reducing ring.” It primarily serves as a sealant [2].

(5) Stuffing box

It is made of packing, which prevents water in the pump from leaking into the surrounding environment and the outside air from entering the pump, thereby maintaining the vacuum state in the pump. The pump shaft and packing generate heat under friction. A water seal tube must be used to inject water into the water seal ring to cool the packing.

(6) Axial force balancing device

When the centrifugal pump is running, liquid is placed at the impeller position under low pressure and flows out under high pressure, resulting in unequal pressure on the left and right sides of the impeller, which effectively generates axial thrust pointing to the inlet position, causing the rotor to move axially and resulting in wear and vibration [3,4]. Therefore, it is necessary to set the axial thrust bearing to balance the axial force.

## 2.2. Working principle

The rotation of the impeller in a centrifugal pump causes the centrifugal pump equipment to operate under the condition of the centrifugal movement of water. Before turning on the water pump, it is necessary to ensure that the water in the pump shell and suction pipe is full. Starting the motor will cause the pump shaft to drive the impeller and water to rotate at high speed. Water is cast out by centrifugal force to the outer edge of the impeller and flows into the water pressure pipe of the pump via the flow channel of the volute pump housing [5,6].

## 3. Key points in the daily operation and maintenance of centrifugal pumps

### 3.1. Key points in the daily operation of centrifugal pumps

The key components of the pump body include the bottom valve, suction pipeline, and mechanical pressure pipe in the mechanical system of a centrifugal pump. With long-term use, the mechanical pressure intensity of the pump body will gradually weaken. Some mechanical operators do not operate and use the centrifugal pump correctly, resulting in damage to the bearing connector, body valve, and body shell, thus affecting the service efficiency of the centrifugal pump [7-9]. Therefore, in the entire operation of centrifugal pumps, mechanical operators must accurately grasp the key points in the operation of centrifugal pumps. Operators and users of centrifugal pumps must exercise reasonable control over the mechanical operation intensity, prevent the mechanical body structure of centrifugal pumps from being damaged caused by excessive mechanical operation intensity, and strengthen the protection of the mechanical system [10].

### 3.2. Key points in the maintenance of centrifugal pumps

Connecting bearings are found in the mechanical system of centrifugal pumps. The bearings of the pump body should be lubricated and maintained on a regular basis; otherwise, the wear and corrosion of these bearings will be accelerated. The working space environment of the centrifugal pump itself has high liquid corrosivity due to the strong acidity of the petrochemical liquid transported by the centrifugal pump. In this case, the maintenance personnel must pay full attention to the lubrication of the connecting bearings of the centrifugal pump, the bottom plate of the pump body, and the shell of the pump body, so as to ensure the operation flexibility of the mechanical parts of the centrifugal pump. In addition, the operation and maintenance personnel should also pay attention to replacing the mechanical parts of the pump body that have corroded. It is important to replace the mechanical parts of the pump body that have lost their normal operative functions, in order to prevent mechanical failure [11-14].

Enterprise technicians should install network intelligent automatic monitoring devices at certain parts of the mechanical infrastructure to monitor the operation in real time. If abnormal operations of the centrifugal pump device and equipment can be timely detected by the technical personnel, it is critical to immediately identify the inducing factors and carry out necessary treatment. The enterprise's technical personnel should perform all-around daily maintenance and supervision of the centrifugal pump facilities, perform necessary lubrication treatment for the centrifugal pump facilities, and replace centrifugal pump components with safety performance risks on a regular basis. Optimizing the start-up mode of centrifugal pump is conducive to reducing the operation cost of mechanical start-up and stop, and it plays an important role in promoting the smooth start-up and stop of the centrifugal pump device system. The centrifugal pump operation control personnel should thoroughly test the centrifugal pump equipment's lubricating oil device, circulating water device, and pump body bottom plate to ensure that the vacuum state of the shaft seal meets the qualified standard, as well as thoroughly optimize the centrifugal pump's existing start and stop control mode.

#### **4. Maintenance of large centrifugal pump units**

In order to effectively deal with the faults of large centrifugal pump units and ensure good operation, these centrifugal pumps need to be overhauled. Relevant maintenance strategies are discussed in this section.

##### **4.1. Mechanical seal**

During the operation of large centrifugal pump units, if the sealing ring fails, the performance of the sealing ring material in high-temperature medium will be potentially threatened, which will lead to the failure of the mechanical seal and affect the application effect of centrifugal pumps in mechanical and chemical production. For such faults, there are several maintenance measures that can be taken.

- (1) Combined with the functional characteristics of the sealing ring, it is necessary to replace the damaged materials on time and implement the troubleshooting of the centrifugal pump's sealing ring in place, so that the sealing ring can play its role in the operation of the large centrifugal pump unit and avoid affecting the implementation effect of the corresponding production plan.
- (2) In the troubleshooting of a large centrifugal pump unit's sealing ring fault, measures such as using inorganic pasting sealant, adjusting interference amount, and improving ring seat material can be taken to eliminate the fault, ensuring more reliable sealing ring performance and providing support for the efficient operation of the large centrifugal pump unit.
- (3) During the maintenance of large centrifugal pump units, in regard to component failure caused by welding heat treatment, corrosion-resistant and high-temperature resistant alloy materials should be used by maintenance personnel to replace the failed components in time. After maintenance, the performance of the components should be evaluated to gauge the operation of the centrifugal pump under the action of the sealing ring, so as to improve the maintenance effect of petrochemical enterprises and avoid potential safety hazards in the operation <sup>[15]</sup>.

##### **4.2. Abnormal noise**

Noise or abnormal vibration of large centrifugal pump units during operation will threaten the safety performance of centrifugal pumps and increase the incidence of operation failure <sup>[16]</sup>. For such faults, petrochemical maintenance personnel are required to carry out corresponding maintenance work to effectively deal with the abnormal sound faults. Several measures can be taken to deal with these faults.

- (1) The centrifugal pump should be shut down immediately to ensure that the impeller is balanced, and the pump shaft and motor shaft are concentric. At the same time, it is necessary to thoroughly inspect whether the large centrifugal pump unit's foundation is firm and whether the rotor rotates in balance. Effective

response work should be implemented to avoid adverse impact on the working performance of large centrifugal pump units.

- (2) When dealing with abnormal sound faults during the operation of centrifugal pumps, petrochemical maintenance personnel also need to consider whether the centrifugal pump inhales sundries and whether cavitation occurs at the impeller inlet. In case of these occurrences, they should be eliminated in time with the support of highly-targeted fault treatment, so as to ensure the effectiveness of the treatment in the petrochemical industry and provide support for improving its operation level.

### 4.3. Other parts

- (1) Maintenance for motor failure

If rotor overload and rotor eccentricity occur during the operation of large centrifugal pump units, the failure rate of the centrifugal pump motor increases, and its working performance suffers, necessitating treatment by maintenance personnel. Among them, when overhauling and dealing with the overload operation fault of the rotor, it is necessary to consider whether the rotating parts have friction problems, realize the disassembly of the pump body, and provide a reliable guarantee for the performance optimization of the rotating parts. At the same time, with the support of the valve control mode, the operation parameters of large centrifugal pump units should be controlled within the design range to meet the requirements of a stable operation. When eliminating the eccentric operation fault of the rotor, petrochemical maintenance personnel need to determine whether the pump has geometric eccentricity or impeller blade vibration, actively adjust the rotor load, and timely eliminate the exciting force caused by eccentricity with the support of comparative test, so as to realize the treatment of centrifugal pump motor fault.

- (2) Maintenance for centrifugal pump impeller fracture

During the use of large centrifugal pump units, if the material performance reliability of the impeller is insufficient and the long-term operation exceeds the fatigue strength, coupled with the stress concentration at the scratch caused by the friction between the impeller and the pump shell, the impeller will be affected by additional stress during use, which indirectly increases the incidence of fracture<sup>[17]</sup>. In light of this failure, petrochemical enterprise maintenance personnel must consider whether the material performance is reliable and whether the stress conditions of high-speed operation are satisfactory based on an understanding of the functional characteristics of centrifugal pump impellers. They should then carry out effective response work to realize the timely treatment of centrifugal pump impeller failure.

### 4.4. Balancing device

The most important operation of large centrifugal pump units is centrifugation. Its main function is to separate liquid through centrifugal force, so as to extract useful parts, separate impurities, and maximize the use of raw materials. If a large centrifugal pump unit is to function normally, it cannot rely solely on the pump shaft and impeller. The balancing device is also an important component that plays a vital role in the entire production process. If the balancing device fails, the large centrifugal pump unit will not function normally. The balance disc is the most easily damaged part of the balancing device when the equipment is running. The balance disc is often worn due to centrifugal force<sup>[18]</sup>. If the wear is serious, it will affect the balance of the entire device. Therefore, it is necessary to maintain the balance of the device and replace the balance disc regularly. In order to further reduce the wear of the balance disc, the frequency of replacement, and the maintenance cost, gaskets can be added on the balance disc to prolong its service life.

#### 4.5. Pump shaft

The pump shaft is an important part of the large centrifugal pump unit, and it should be paid attention to during maintenance. During the operation of large centrifugal pump units, the pump shaft rotates at high speed, which produces strong centrifugal force through the cooperation between the pump shaft and the rotor, relies on the engine, and provides power through the rotor. The impeller installed on the bearing is rotated at high speed to separate the liquid <sup>[19,20]</sup>. The liquid of varying qualities is layered, and finally the effective components and the impurities are separated. Due to the high-speed rotation, the pump shaft will inevitably wear, and various faults will occur under the centrifugal force. Therefore, in order to ensure a normal operation, it is necessary to carry out regular maintenance, focus on the inspection of the pump shaft, and replace the damaged parts in time, so as not to disrupt the entire production process and jeopardize the interests of enterprises.

#### 5. Conclusion

In conclusion, the common faults of large centrifugal pump units involve the mechanical seal, balancing device, pump shaft, abnormal noise, and other faults. Ensuring the proper operation of centrifugal pump units can help the industry grow. The stable operation of centrifugal pump units can also improve production efficiency, thereby driving the development of the industry and enterprises. It is particularly important to strengthen the daily maintenance and inspection of centrifugal pump units as their service life can be extended with regular maintenance and inspection.

#### Disclosure statement

The author declares no conflict of interest.

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